INFLUENCE OF MULCHING MATERIALS, METHODS AND HERBICIDE APPLICATION ON GROWTH AND DEVELOPMENT OF CUCURBITS

by

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B. S. (Agriculture), Kansas State University, 1964

A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1967

Approved by:

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TABLE OF CONTENTS

INTRODUCTION

For centuries man has faced the problem of reducing or overcoming the environmental limitations of crop production. For much of the cultivated land surface of the earth, the season of active plant growth is limited by annual temperature fluctuations. Many of the frost susceptible plants cannot be successfully grown when exposed to killing spring frosts and even when that danger is past, growth will be slow until the soil temperature is suitable. When climatic factors stimulate active plant growth crop plants and weeds will grow rapidly. Coal or oil burners, sprinkler irrigation systems, artificial and vegetative screens, smoke screens, flooding, hotcaps, and plastic tents have been used with varying degrees of success to protect plants from frost damage (5). Weeds may be controlled by hand pulling, hoeing, tilling, burning, and by biological and chemical control measures (4).

Mulches have been used to create more favorable temperatures for crop growth and to reduce the detrimental effects of weed competition. Mulching is generally limited to use on high per acre value crops where the expense involved can be offset by increased income per acre or reduced labor costs, etc. Numerous horticultural crops are mulched, but apparently the cucurbits respond as well, or better to mulching than any major horticultural crop (10).

A mulch, as defined in the 1957 U.S.D.A. Yearbook of Agriculture, is a natural or artificially applied layer of plant

residues or other materials on the surface of the soil. In addition to their primary use of reducing the detrimental effects of weeds and low temperatures on crops, mulches are used for moisture conservation, prevention of soil surface compaction, and for erosion control. The effectiveness of a mulch is dependent upon the cost of material, cost of application, overall reduction in production costs, increase in crop value, and the seasonal climatic conditions.

Many organic and inorganic materials have been tested and used as mulches with varying degrees of success. Both clear and black polyethylene films have been introduced as mulching materials in recent years and have been well accepted for extensive use in the production of numerous crops. The petroleum asphalt emulsions which show many similarities and some possible advantages over the polyethylene films are being studied as potential mulching materials. These are water emulsions of petroleum resins. The bulk density of an asphalt emulsion (8.4 pounds per gallon) is nearly equal to that of water which makes possible application to the soil surface with a pressure sprayer at temperatures of 60 to 70°F., or above. Asphalt emulsion dries and sets rapidly forming a very close adhering soil covering.

Seedling emergence is apparently not retarded by petroleum asphalt mulch whereas polyethylene film must be cut to allow the seedling to emerge. The band width of the asphalt mulch may easily be varied with a conventional sprayer. Another possible advantage of asphalt mulch is that polyethylene will not

deteriorate and must be removed from the field, whereas the asphalt mulch will deteriorate in a few months thus not requiring removal.

The purpose of this study was to compare the effectiveness of a petroleum asphalt emulsion and black plastic as mulches for increasing early marketable yields of selected horticultural crops under Kansas conditions. Further comparisons were made with asphalt mulch used in combination with clear plastic. Also, the asphalt mulch was used with and without a combined herbicide.

REVIEW OF LITERATURE

Petroleum asphalt emulsion has been evaluated as a soil mulch for a number of crops in California, Arizona, Colorado, Texas, and Florida (2,6,7,11,13). Crop response to asphalt mulch has been tested with tomatoes, cucurbits, onions, beets, snap beans, sweetcorn, sugar beets, small grains, cotton, and range grasses. Favorable results have been reported with most crops depending on the desired response, however, there is some question of the economic feasibility of using the material for crops other than those of relatively high per acre value.

Increase in germination and initial emergence for all crops tested under petroleum mulch in band widths of 3, 6, 12, and 24 inches were reported by Takatori et al., in California. Bement et al., in rangeland seedling studies at Ft. Collins, Colorado found that emergence of blue grammagrass was increased by 23 days and second year survival was also increased by the asphalt mulch. Increased cotton seedling emergence of over 200 percent with petroleum mulch was noted at Spur, Texas (7).

Weed control appears to be a major problem with the use of petroleum mulch. Increased growth of both broadleaf and grassy weeds was observed by Wiggans and Kays and by Lippert et al., (8,14). The weed control response of several herbicides was not impared when combined with petroleum mulch before application. Amiben, 2,4-D amine, DCPA, DMPA and Pennsalt TD-62 applied before or in individual mixtures with the asphalt mulch gave satisfactory weed control responses (1,9).

Temperature increases on the soil surface and immediately below as a result of asphalt mulches have been indicated in several reports (3,6,7,11). Black reports that an application of asphalt mulch to a 10 by 10 foot square plot raised the temperature one half inch below the soil surface by almost 19 degrees F. during maximal daytime temperatures and during the coolest part of the night the temperature remained 4 degrees F. above that of nonmulched soil. In California studies a six inch wide band of asphalt mulch raised the soil surface temperature 18 degrees F. over bare soil temperature during the middle of the day. In these same studies the increase in soil surface temperature from the use of clear and black polyethylene film was less than half the increase by asphalt mulch, however the night time low temperature of the soil surface was lower for asphalt mulch than either clear, or black polyethylene (11).

Soil temperature differences between black polyethylene and asphalt mulch is believed to be due to difference in contact with the soil surface. The air pockets under the polyethylene serve as insulation whereas no air pockets exist under the asphalt mulch (12).

An increased retention of soil moisture by petroleum asphalt mulch was believed to largely account for the increased rate of seed germination and subsequent seedling growth in the Colorado range seeding studies (2). Hatchett and Bloodworth report soil moisture at seed level (3 inches) maintained at a higher level for a 4 to 5 day period after planting and application of

asphalt mulch under dryland conditions. Soil moisture retention due to asphalt mulch does not differ significantly from that of polyethylene film. Width of the asphalt band does appear important with the wider bands (12 to 24 inches) offering greater moisture retention (8).

MATERIALS AND METHODS

A study of the influences of asphalt mulch on the growth rate of selected cucurbit crops was conducted in growth chambers, greenhouses and at the Ashland Horticulture Farm at Kansas State University in 1964 and '65. The asphalt emulsion, formulated as SS-IH Mulch Emulsion by Kansas Emulsion, Inc., of Eldorado, Kansas and supplied by Skelly Oil Company of Kansas City, Missouri, was mixed with equal parts of water and sprayed on the soil surface following planting.

Preliminary tests were conducted in growth chambers to observe plant response to variations in asphalt mulch thickness. Application rates giving 5, 7.5, 10, 15, and 20 mils thickness were observed. The rate of application was measured by placing a hand operated pressure sprayer and contents on a solution balance (Plate I) and weighing out the exact amount in grams required for the surface area to be sprayed.

The preliminary tests were conducted on squash (Early Summer Crookneck), cucumber (Ashley), muskmelon (PMR 45), and watermelon (Charleston gray) during the fall of 1964. The growth chambers were operated on a cycle of 12 hours of light and 12 hours of darkness. Soil, taken directly from a field planted the previous season to muskmelons and watermelons, was placed in plastic lined greenhouse flats (Plate I) which served as planting beds. In the preliminary tests only one-half of each flat was sprayed and the other half was masked with cardboard to serve as a control.

Observations during the preliminary tests indicated that both crop and weed seed germination was increased by the asphalt mulch at all application rates when compared to the control. See Plate II. Observations of differences between rates were generally inconclusive. A favorable response was obtained fairly consistently with an application of 48 gallons of actual asphalt emulsion per acre which gave a 10 mil thickness mulch.

Following and guided by results from the preliminary tests, three experiments were conducted comparing the effect of asphalt emulsion mulch and no mulch on the germination of cucurbit crops, the effect on soil temperature, and the possibilities of effective weed control by mixing a selective herbicide with the asphalt emulsion before application. Asphalt mulch and black plastic mulch were compared. One additional treatment was designed to compare the effect of asphalt mulch used in combination with clear film plastic to the other treatments. The influence of all treatments on earliness of maturity and marketable yield were compared.

Description of Experiments

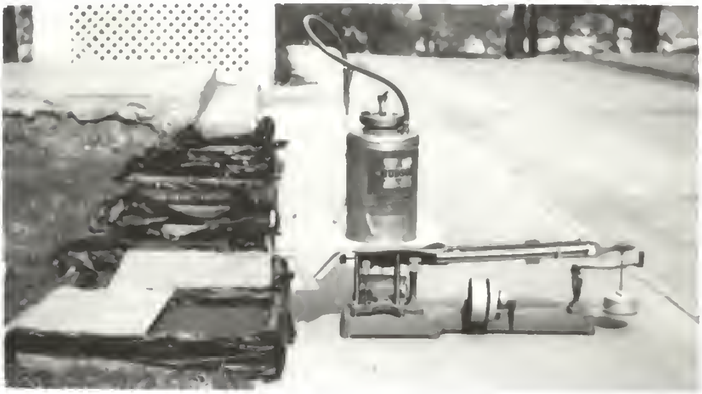
Experiments One and Two. Experiment one was planted November 13, 1964 and was terminated 12 days later. The experiment was conducted in growth chambers operating on a 12 hour light--12 hour darkness cycle. The air temperature in the growth chamber as indicated in Fig. 3 ranged between 64 degrees F. and 79 degrees F.

EXPLANATION OF PLATE I

Top. Rate of asphalt application was determined by placing the sprayer on a solution balance. Note plastic lined greenhouse flats (14" x 22" x 3") used as planting beds.

Bottom. Laying clear polyethylene film to form a tent over the asphalt mulch on one side of furrow in field.

Plate I



Experiment two was planted December 4, 1964 and was terminated 18 days later. The experiment was conducted in the greenhouse with temperatures as indicated in Fig. 4 ranging between 59 degrees F. and 70 degrees F.

Three treatments: (a) 10 mils thickness of asphalt mulch, (b) 10 mils of asphalt mulch combined with a selective herbicide and (c) control, were replicated 4 times in both experiments one and two. The same materials and methods as described for the preliminary tests were used except that the entire surface of each greenhouse flat was treated rather than only one-half the surface. Entire flats were used for controls as shown in Plate II.

One row each of the four previously described crops with 50 seeds per row were planted in each flat. Approximately a teaspoonful of seed of five common Kansas weeds (Amaranthus spp., Ipomea spp., Setaria spp., Digitaria spp., and Abutilon theoprasti) were added to the soil in each flat to increase the weed population. Soil moisture was maintained at near optimum by hand watering.

The selective herbicide, Alanap-3 (Sodium salt of N-1-naphthylphthalamic acid), was mixed with the asphalt emulsion prior to application. The Alanap-3 was applied according to the manufacturers recommended rate of two pounds of actual material per acre.

Plant response to the asphalt mulch and to Alanap-3 was measured by determining the number of days from planting to first

seedling emergence, percent of crop seed germinated and living 12 days after planting, and the number of live weed seedlings present 12 days after planting. Results of experiment one are shown in Fig. 1 and 2 and in Table 1. Results of experiment two were very similar to those of experiment one except that a longer time for germination was required. The temperature data of experiment two are given in Fig. 4.

Temperatures in asphalt mulched and non-mulched soils were recorded with a double lead soil thermograph. The thermograph bulbs were buried at seed level (one inch). Air temperature was recorded simultaneously with an air thermograph. The results are shown in Fig. 3 and 4.

Experiment Three. Experiment three was conducted in the field during the spring and summer of 1965. The effectiveness of asphalt mulch alone, in combination with and in contrast to polyethylene films, and with Alanap-3 were measured. The 5 mulching treatments used were: (a) a 12 inch wide 10 mil thickness band of asphalt mulch referred to hereafter as asphalt mulch (Plate III), (b) a 12 inch wide band of asphalt mulch (10 mils) under a "tent" of 4 mil clear polyethylene referred to hereafter as asphalt-clear plastic (Plate I), (c) control, (d) bare soil under a "tent" of 4 mil clear polyethylene referred to hereafter as clear plastic, and (e) a $1\frac{1}{2}$ mil black polyethylene film directly on the soil surface referred to hereafter as black plastic (Plate V). Each treatment was replicated 4 times in rows 48 feet long running north-south, on a fine sandy

loam soil. The field study included the same treatments on both watermelons, (Crimson Sweet), and muskmelons (PMR 45). Row spacings were 10 feet apart for watermelon and 5 feet for muskmelons. The mulch treatments in each test were arranged with a randomized block design. Tests for herbicidal effectiveness in combination with the mulching materials were conducted with a split plot application technique superimposed on the above treatments (Plate V). Alanap-3 was applied at a rate of one gallon per acre, incorporated with the asphalt emulsion, and as a pre-application under the polyethylene materials. Although no herbicidal effect was expected, Alanap-3 was applied under black plastic in order to achieve a uniform plant treatment, thereby making a statistical analysis possible.

The asphalt mulch was applied with a 3 gallon hand operated pressure sprayer equipped with a T-Jet flat fan nozzle. A rate of 48.4 gallons per acre surface covered was used to give a 10 mil thickness.

The tents of clear polyethylene were constructed by plowing a single furrow with a moldboard plow and rolling the sloping side of the furrow with a 200 pound lawn roller. Seeds were planted about half way up the side slope and the clear polyethylene film was stretched flat across the furrow (Plate I). The clear polyethylene tents were used (1) as described, and (2) with a 12 inch band of asphalt sprayed on the side slope (Plate IV).

The number of plants per hill and hills per row were

recorded to compare the rate of emergence between treatments. Counts were made at approximately 2 day intervals beginning when the first emergence was noted and continuing until seedlings in most hills for all treatments emerged. The results are recorded in Table 2.

The rate of early growth between mulch treatments was determined by measuring the rate of development of true leaves. The results are recorded in Tables 3 and 4.

Early maturity was evaluated by comparing the rate of first blossom initiation. The first blossoms were almost entirely staminate and later counts included progressively more pistillate flowers. All hills were thinned to 2 plants at about the time the first flower buds appeared, consequently all blossom counts were made on a comparable number of plants per hill. First fruit set was used as an additional measurement of earliness. The results are recorded in Table 5.

The average number of weeds per foot in a 6 inch wide strip centered on the plant row was taken as a measure of herbicide effectiveness. Measurement of the possible effect of herbicide on crop growth and development was made by comparing the initial fruit set per plant, and fruit size between the herbicide treated and non-treated plots. The results are recorded in Tables 6 and 7.

Early marketable yield and size of mature fruit was measured between mulch and herbicide treatments. This was done to determine the possible economic potential of the materials and the

methods of application. Early marketable yield is considered more important than total yield since the early season price is usually higher. Yield was measured in pounds per acre of marketable fruit from each treatment until all treatment plots had produced at least one marketable fruit. Non-marketable fruits were not considered. The results are given in Table 8.

RESULTS

Experiments One and Two. Germination percentages at 12 days after planting were increased for all 4 crops by using 10 mils of asphalt mulch. The actual germination percentages were far below the minimum legal germination percentages as set forth in the Federal Seed Act. However, as shown in Fig. 1 all crops so treated showed a definite increase in germination percentage. See Plate II.

The asphalt mulch reduced the time required for seedling emergence by an average of 2.72 days for all crops (Fig. 2). The variation between crops in time required for seedling emergence was comparable to the variation in germination percentages. The greatest increase in germination percentage was from squash with a 23.4 percent increase. Squash also showed the greatest reduction in time (3.5 days) required for emergence.

Weed seedling population was increased by asphalt mulch (Plate II and Table 1). The increase of grassy type weeds was notably greater than the increase of broadleaf weeds. Alanap-3 applied in mixture with the asphalt mulch gave partial control of both broadleaf and grassy weeds, however the population of grassy weeds was greater with the asphalt and Alanap-3 than on the control. See Table 1. The days to emergence of weed seedlings was reduced by the asphalt mulch but the reduction was apparently completely counteracted by the addition of Alanap-3. See Plate II for comparison of the three treatments.

Soil temperatures at a one inch depth were raised by the

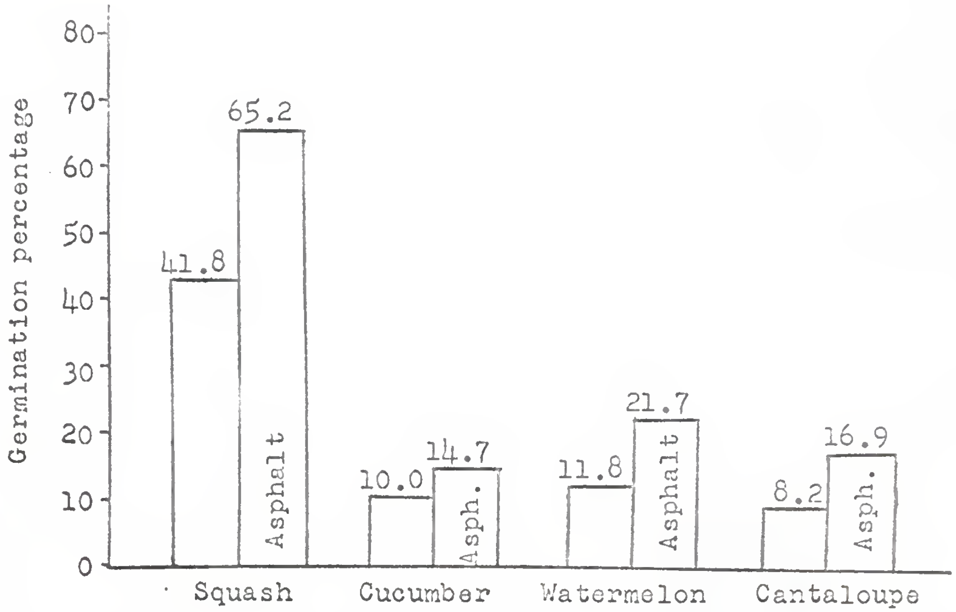


Fig. 1. Increased germination percentages of 4 vine crops 12 days after planting by use of a 10 mil asphalt emulsion film in a growth chamber operating on a 12 hour-day light cycle.

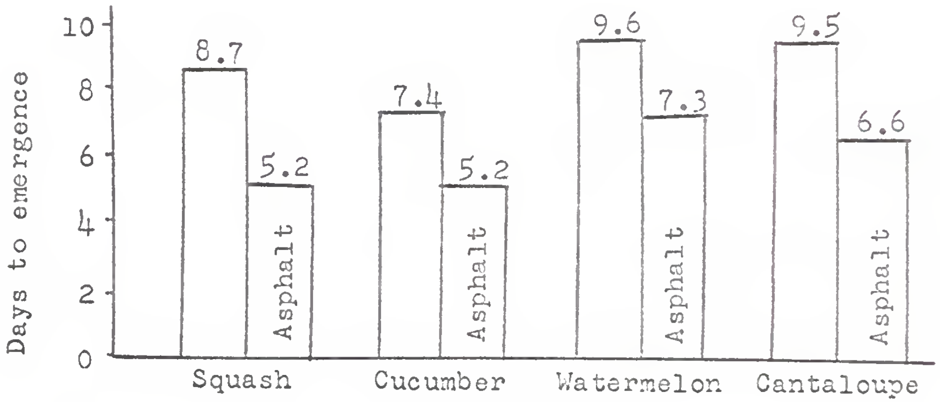


Fig. 2. Number of days required for seedling emergence of 4 vine crops with a 10 mil asphalt emulsion mulch in a growth chamber operating on a 12 hour-day cycle.

EXPLANATION OF PLATE II

Top. Crop and weed seedling response to asphalt mulch during preliminary observations in the *growth chamber*.

Center and Bottom. Control of weeds by mixing herbicide with asphalt emulsion before spraying it on the soil.

Bottom. Left to Right - No asphalt or Alanap-3, asphalt but no Alanap-3, asphalt and Alanap-3.

Plate II

Table 1. Effect of asphalt mulch (10 mils thickness) combined with Alanap-3 on density and earliness of weed seedling population in the growth chamber operating on a 12 hour day cycle.

Treatment	Average number of weeds per flat*		Average days to emergence of first weed
	Dicot	Monocot	
Control	26.5	11.5	5.25
Asphalt	35.9	58.2	3.3
Asphalt and Alanap-3**	14.9	39.9	5.2

*Count taken 12 days after planting crop.
**Alanap-3 applied at the rate of one gallon per acre surface in mixture with asphalt emulsion.

asphalt mulch and maintained at a higher level than the non-mulched soil. Temperatures of the control were never above the air temperature. Temperatures of the asphalt mulched soil ranged above air temperature in the afternoons and evenings. The temperature of the non-mulched soil ranged 4 to 8 degrees F. below the temperatures of the air and the asphalt mulched soil, as indicated in Fig. 3 and 4.

Experiment Three. Early stand establishment of watermelons was increased by clear plastic at a rate significantly greater than the rates of the other treatments. For a short time early in the season asphalt-clear plastic showed a favorable stand establishment but as shown in Table 2 a stand reduction later occurred. The control gave poor stand establishment early in the season but showed later gains. Black plastic showed no evidence

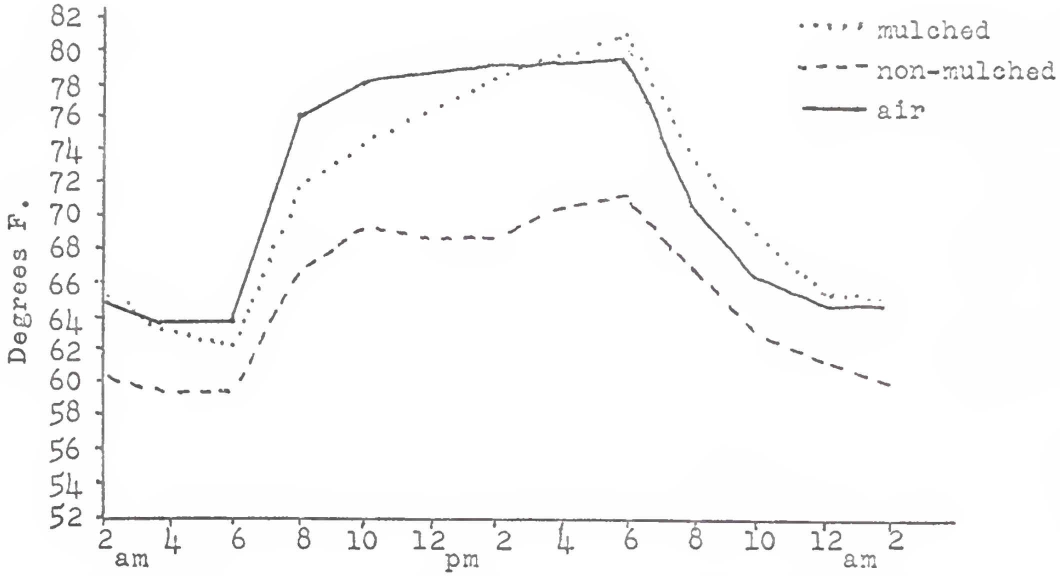


Fig. 3. Average daily temperature variation between asphalt mulched and non-mulched soil at one inch depth and air temperature just above the soil surface in growth chambers operating on a 12 hour-day (6am-6pm) eight cycle.

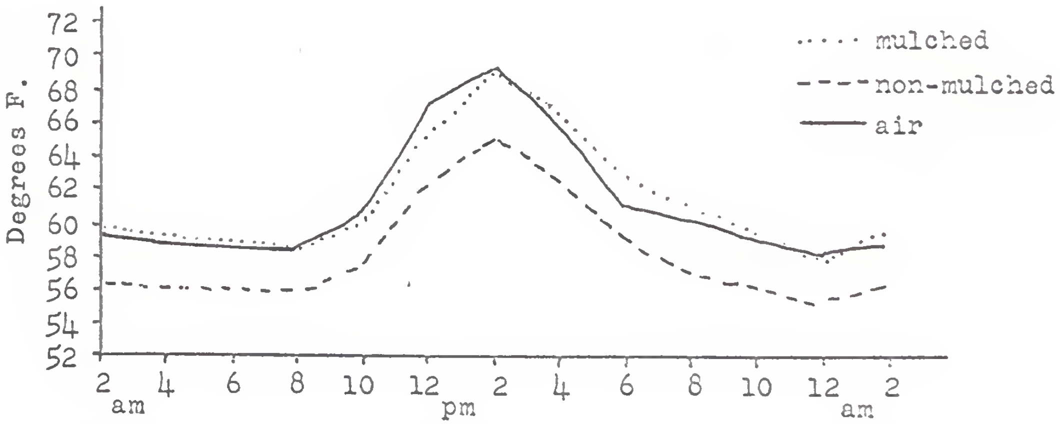


Fig. 4. Average daily temperature variation between asphalt mulched and non-mulched soil at one inch depth and air temperature just above the soil surface in a greenhouse under winter (December) conditions.

Table 2. Establishment of early stand with 5 mulching treatments in the field experiment planted April 23, 1965. Approximately 8 seeds per hill were seeded in 12 hills per row.

Treatment	Plants Per Row		Hills Per Row	
	May 4*	May 12**	May 4	May 12
	Watermelons			
Asphalt	46.50	39.50	11.25	10.00
Asphalt-C. Plastic	53.00	42.50	10.75	9.75
Control	23.50	39.00	8.00	10.75
Clear Plastic	61.25	63.75	11.75	11.50
Black Plastic	16.75	20.75	7.75	7.75
	Cantaloupe			
Asphalt	57.75	68.25	11.00	11.25
Asphalt-C. Plastic	34.25	21.25	9.75	7.00
Control	6.75	41.25	2.75	10.25
Clear Plastic	59.00	49.00	11.50	10.25
Black Plastic	20.25	22.00	6.00	7.00

*L.S.D. = 9.365 at the 5% level for watermelons; L.S.D. = 18.865 at the 5% level for cantaloupe.
**L.S.D. = 14.883 at the 5% level for watermelons; L.S.D. = 25.294 at the 5% level for cantaloupe.

of increasing the early stand establishment of field seeded watermelons.

Early stand of cantaloupe was initially increased by asphalt and by clear plastic. However by the second stand count no significant difference was apparent between clear plastic and the control. As with watermelons, the black plastic gave no evidence of promoting establishment of an early stand of field seeded cantaloupe. Asphalt-clear plastic gave very poor early stand establishment of cantaloupe.

Following early stand establishment recordings (Tables 2 and 3) all treatments were thinned to not more than 2 plants per hill.

Table 3. Average number of plants with true leaves developed by May 12 with 5 mulching treatments in the field experiment planted on April 23.

Treatment	Watermelons*	Cantaloupe**
Asphalt	38.50	65.50
Asphalt-Clear Plastic	37.25	17.78
Control	31.75	36.00
Clear Plastic	55.25	41.75
Black Plastic	17.50	19.75

*L.S.D. = 15.475 at the 5% level.
**L.S.D. = 25.252 at the 5% level.

Early growth of the crops as measured by development of true leaves was encouraged by asphalt-clear plastic and black plastic on both crops. At the time of the first measurement the asphalt-clear plastic appeared to be giving the most rapid development, but by approximately 10 days later the greatest response was to black plastic. As indicated in Table 4, development of true leaves on both crops by the second reading was greater with black plastic than with asphalt-clear plastic, however the difference was significant only on cantalcupe. The time interval between readings was greatest for cantaloupe.

Both crops set female blossoms at a significantly greater rate with black plastic than with any of the other mulch treatments. Although black plastic showed a significantly greater female blossom set when compared to asphalt, asphalt-clear plastic, control, and clear plastic no significant difference was evident between these latter four mulch treatments on either crop.

Alanap-3 applied in conjunction with the mulching treatments controlled weeds in the non-mulched control on both crops (Plate V). The weed population in both crops a month after planting was significantly lower in the Alanap-3 treated portion of the non-mulched control.

Some weed control was also evident with Alanap-3 on asphalt and clear plastic mulch treatments. The Alanap-3 treated portion of the asphalt mulched watermelon showed a significantly lower weed population at 30 days after planting. The same

Table 4. Average development of true leaves per plant with 5 mulching treatments following planting on April 23.

Watermelons

Treatment	May 21*	May 29**
Asphalt	2.927	5.075
Asphalt-Clear Plastic	3.365	5.441
Control	2.539	4.558
Clear Plastic	3.010	5.058
Black Plastic	2.881	5.875

*L.S.D. = 0.2253 at the 5% level.
**L.S.D. = 0.622 at the 5% level.

Cantaloupe

Treatment	May 22*	June 4**
Asphalt	3.078	4.007
Asphalt-Clear Plastic	3.968	7.203
Control	2.819	4.102
Clear Plastic	3.503	5.978
Black Plastic	3.387	10.237

*L.S.D. = 0.2996 at the 5% level.
**L.S.D. = 1.512 at the 5% level.

Table 5. Average blossoms set per plant on June 23, planted with 5 mulching treatments on April 23.

Treatment	Watermelons*	Cantaloupe**
Asphalt	0.375	1.125
Asphalt-Clear Plastic	0.750	1.125
Control	1.125	0.750
Clear Plastic	1.125	1.125
Black Plastic	3.142	2.485

*L.S.D. = 1.136 at the 5% level.
**L.S.D. = 0.437 at the 5% level.

treatment reduced the weed population in cantaloupe but not significantly. The weed population under clear plastic mulch was reduced with Alanap-3, the reduction in cantaloupe was significant but in watermelon the reduction was non-significant.

As indicated in Table 6, Alanap-3 was used with the black plastic and a very slight reduction in weed population was recorded (Plate V). The reason for this treatment was to allow a uniform statistical analysis. The measured difference in weed population was insignificant.

No adverse effects of Alanap-3 on fruit set were observed. As indicated in Table 7 the average number of fruit set per plant was greater in all but one case where Alanap-3 was used than where it was not used. Where Alanap-3 was not used with black plastic on watermelons a greater number of 6 inch diameter or larger fruit were set on July 14.

Table 6. Average weed population per foot of row with and without Alanap-3 in each of 5 mulching treatments.

Mulch Treatment	Alanap-3		No Alanap-3
	Watermelons, May 23*		
Asphalt	2.450	---	5.950
Asphalt-Clear Plastic	0.925		0.700
Control	0.900	---	4.650
Clear Plastic	3.275		4.500
Black Plastic	0.000		0.025
	Cantaloupe, May 30**		
Asphalt	6.625		8.000
Asphalt-Clear Plastic	1.475		2.500
Control	2.825	---	6.000
Clear Plastic	1.775	---	5.275
Black Plastic	0.000		0.050

*L.S.D. = 3.164 at the 5% level.
**L.S.D. = 2.383 at the 5% level.

A noticeable increase in the number of larger sized fruit per plant was evident at an early date on both crops where black plastic was used regardless of the herbicide treatment. As indicated in Table 7 the number of larger sized fruits per plant on watermelons was more than doubled by the use of black plastic. Also the larger sized cantaloupe were present on black plastic before any other treatment. The early fruit set and fruit size of cantaloupe were recorded approximately 2 weeks before the

Table 7. Initial fruit set per plant and according to size following the use of 5 mulch treatments with and without Alanap-3.

Watermelons*

Mulch Treatments	Fruit size 0" to 6"		Fruit size over 6"	
	Alanap-3	No Alanap-3	Alanap-3	No Alanap-3
Asphalt	2.75	1.25	3.00	1.25
Asphalt-Clear Plastic	2.00	1.25	3.75	3.25
Control	1.25	0.75	3.50	0.75
Clear Plastic	2.25	2.00	4.50	4.00
Black Plastic	2.25	1.74	10.25	11.25

*July 14

Cantaloupe*

Mulch Treatments	Fruit size 0" to 2"		Fruit size over 2"	
	Alanap-3	No Alanap-3	Alanap-3	No Alanap-3
Asphalt	0.25	0.00	0.00	0.00
Asphalt-Clear Plastic	0.25	0.25	0.00	0.00
Control	1.00	0.25	0.00	0.00
Clear Plastic	1.00	0.00	0.25	0.00
Black Plastic	2.00	1.75	3.25	1.75

*June 25

watermelon recordings, as is indicated in Table 7.

Early yield measurements showed a correlation between initial fruit set and early yield per acre. As indicated in Table 8 the highest early yields per acre were from the black plastic on both crops (Plate V). Black plastic increased watermelon yields during the early harvest period by 14 thousand pounds per acre over any of the other mulch treatments, or just less than twice as much as the next highest yield which was from the asphalt-clear plastic mulch treatment. Cantaloupe yields during the early harvest period were increased with black plastic by just less than 12 thousand pounds per acre over any of the other mulch treatments, or over 4 times greater than the next highest yield which was from asphalt-clear plastic.

All 4 mulching methods used without Alanap-3 gave an increased yield per acre over the non-mulched control in both crops. Alanap-3 used with asphalt and the non-mulched control increased the yield per acre of both crops over no Alanap-3 with the same mulching treatments. Asphalt-clear plastic, clear plastic, and black plastic mulches used with Alanap-3 gave higher yields than the non-mulched control with Alanap-3 in watermelons but not in cantaloupe. Asphalt mulch with Alanap-3 increased the yield over the non-mulched control with Alanap-3 in cantaloupe but not in watermelons.

The average watermelon weights at harvest were greater with the black plastic than with any of the other mulching treatments. Also the average watermelon harvest weights were greater

Table 8. Average early yield per acre and fruit size in pounds after using 5 mulching treatments with and without Alanap-3.

Mulch Treatment	Average half acre yield		Average fruit size	
	Alanap-3	No Alanap-3	Alanap-3	No Alanap-3
	Watermelons*			
Asphalt	7281.05	3537.07	20.89	20.30
Asphalt-Clear Plastic	15200.26	3310.56	20.52	19.00
Control	9395.89	1968.91	17.57	15.06
Clear Plastic	13597.25	4876.54	20.81	18.65
Black Plastic	19407.72	13886.92	23.44	21.25
	Cantaloupe**			
Asphalt	1940.59	1446.19	2.62	2.55
Asphalt-Clear Plastic	1550.73	2073.45	2.73	3.17
Control	1047.61	873.37	2.40	2.50
Clear Plastic	1034.55	1132.56	2.63	2.60
Black Plastic	7803.77	7810.30	3.03	3.14

*Harvest period from July 30 to August 13.
**Harvest period from July 20 to August 6.

in every mulch treatment with Alanap-3 than without Alanap-3. The watermelon weight variations between Alanap-3 and no Alanap-3 ranged from .59 pounds on asphalt mulch to 6.51 pounds on the non-mulched control.

No definite trends in the harvested fruit weight of cantaloupe were apparent. However the average cantaloupe weight at

harvest was generally higher on black plastic than on any of the other treatments.

EXPLANATION OF PLATE III

Twelve inch wide band of asphalt mulch over a row of field seeded watermelons.

Plate III

EXPLANATION OF PLATE IV

Top. Furrow in field after removal of clear plastic "tent" showing asphalt mulched side slope and plant growth.

Bottom. Furrow in field after removal of clear plastic "tent" showing non-treated side slope and plant growth.

Plate IV

EXPLANATION OF PLATE V

Top. Control of weeds with herbicide in a row with no mulch treatment. Herbicide in foreground, check in back.

Bottom. Left to Right - Black polyethylene mulch and no mulch treatment.

Plate V

DISCUSSION

As a result of this study it is evident that seed germination is increased by asphalt mulch (Plate II). The increase in germination of both crop and weed seeds may be due in part to the increase in soil temperature resulting from use of the asphalt mulch. The temperature recordings in this study are in accord with the results obtained by Takatori et al., in California (11).

Apparently weeds can be controlled by applying a selective herbicide with the asphalt emulsion (Plate II and V). However, the rates used in this study did not give satisfactory control, either in the growth chambers and the greenhouse or in the field. In the growth chamber study the population of dicot weed seedlings was increased over the control by the asphalt mulch, but was reduced to a lower level than on the control by adding Alanap-3 to the asphalt mulch. The monocot weed seedling population was increased over the control by the asphalt mulch and although to a lesser extent, was also increased by the asphalt mulch with Alanap-3 added.

In the field experiment Alanap-3 applied with the asphalt showed a reduced weed population 30 days after planting. The reduction of weed population in watermelons was significant while in cantaloupe it was not. The weed population in cantaloupe was measured 7 days after the watermelon weed population which may account for the lack of significance.

Of the 4 mulching methods used only black plastic was

consistently below the control in early stand establishment and early plant development. This would indicate a possible undesirability of direct seeding through black plastic. The most overall significant increases in stand establishment and early plant development were from the mulch treatment (Plate IV). In the field experiment cantaloupe gave a favorable early response to asphalt but watermelon did not.

Approximately 30 days after seeding the plants on black plastic began to out-perform the plants in the other mulch treatments and in the control (Plate V). This became clearly evident as the female blossoms began to set. The black plastic gave almost perfect weed control and a large increase in early fruit development. The yield with black plastic was nearly double the yield with any of the other mulch treatments on either crop. The average fruit weight at harvest was greater with black plastic than with any of the other mulch treatments.

Satisfactory control of weeds in the row of both crops was obtained with Alanap-3 where no mulch treatment was used. The weed population in both crops at 30 to 40 days after planting and herbicide application was significantly lower with the Alanap-3 where no mulch treatment was used. In watermelons at 30 days after planting the weed population was significantly lower where Alanap-3 was used with asphalt mulch than where it was not. A week later the weed population in cantaloupe was lower with Alanap-3 and asphalt mulch but not significantly lower than for asphalt mulch without Alanap-3. The week

difference between the watermelon and cantaloupe weed counts may have accounted for the lack of a significant difference between Alanap-3 and no Alanap-3 on the asphalt mulched cantaloupe.

Some trends in yield response of both crops to the mulching and herbicide treatments used are evident in Table 8. As previously stated the yields with black plastic were greatly increased regardless of the herbicide treatment. Where no Alanap-3 was used all 4 mulch treatments gave yield increases over the control. Yield was increased by the use of Alanap-3 on the non-mulched control and on the asphalt mulch.

Conclusions

From these facts it might be concluded that:

Cucurbits may be expected to yield slightly better with asphalt mulch and even better gains may be expected when Alanap-3 is used with the asphalt.

Alanap-3 may be expected to increase the yield of cucurbits where a plastic mulching material is not used.

Black plastic mulch may be expected to increase the yield of cucurbits considerably more than asphalt mulch used with or without Alanap-3.

ACKNOWLEDGEMENTS

The author wishes to express his most sincere gratitude to his major advisor, Dr. Charles V. Hall, for his patient and continuing help and encouragement while conducting the study and in the preparation of this thesis.

I would like to express my appreciation to Dr. Ronald W. Campbell and Dr. Robert P. Ealy, head and former head respectively, of the Department of Horticulture and members of my graduate committee, for their encouragement and assistance in this work.

My thanks goes to Mr. Rollin Smith, Skelly Oil Company, Kansas City, Mo., for his help in determining the rate of asphalt application to obtain a given film thickness, and to Skelly Oil Company for supplying the asphalt emulsion.

I am indebted to Dr. John C. Frazier for serving on my graduate committee and for his interest in the study.

The assistance given by Mr. George E. Slagle and Mr. Lewis Chapman of the horticulture farm is greatly appreciated.

The interest shown by all members of the horticulture department in the course of this study is appreciated.

My very deepest appreciation to my wife Beulah for her help and encouragement throughout my graduate studies at Kansas State University.

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INFLUENCE OF MULCHING MATERIALS, METHODS AND HERBICIDE APPLICATION ON GROWTH AND DEVELOPMENT OF CUCURBITS

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State University, 1964

AN ABSTRACT OF A MASTER'S THESIS

submitted in partial fulfillment of the

requirements for the degree

MASTER OF SCIENCE

Department of Horticulture

KANSAS STATE UNIVERSITY
Manhattan, Kansas

1967

Temperature variations and weeds are important environmental limitations of crop production. Mulches have been used to counteract the undesirable effects of both these factors. The cucurbits show the most favorable response of all crops to mulching.

Petroleum asphalt emulsions are the most recently introduced mulching material. The bulk density of these water emulsions of petroleum resins is nearly equal to water. The emulsion drys and sets rapidly when applied to the soil surface at normal daytime temperatures. Petroleum asphalt mulch shows several possible advantages over plastic mulching materials.

Petroleum asphalt mulch has been tested on a wide range of economic crops in widely separated areas of the country. Seed germination, seedling emergence, and stand survivability were apparently improved by the asphalt mulch. Higher soil temperatures and greater soil moisture retention are believed to be major factors accounting for the improved plant response. Weed control appears to be the predominant problem in the use of asphalt mulch.

A study of the effects of asphalt mulch on cucurbits was made at Kansas State University in 1964 and '65. The first tests of the asphalt mulch (Supplied by Skelly Oil Company of Kansas City, Mo.) were conducted in growth chambers on squash, cucumber, muskmelon, and watermelon. In the initial experiments asphalt mulch improved germination and seedling emergence considerably. Soil temperature response was comparable to those

in studies by other workers. Tests conducted in the growth chamber and later tests in the greenhouse indicated that weeds could be controlled by mixing Alanap-3 with the asphalt prior to application.

An experiment to compare the effects of asphalt mulch, clear and black plastic mulches, and a combination of asphalt and clear plastic mulch on muskmelons and watermelons was conducted in the field during the spring and summer of 1965. A split plot herbicide test with Alanap-3 was superimposed on the mulch treatments in an effort to determine the effectiveness of an herbicide used in combination with the mulching treatments. Plant response to treatments was measured by comparisons of seedling emergence, early stand establishment, early maturity (true leaf and blossom development), weed populations, early fruit set, marketable yield per acre, and size of harvested fruit.

Seedling emergence and early stand establishment of watermelons were improved over the control by the asphalt-clear plastic treatment. Cantaloupe gave the greatest emergence and early stand response to asphalt alone. Black plastic retarded seedling emergence and early stand establishment. The clear plastic was removed soon after the seedlings were established. In the initial measurements of early maturity the plants under clear plastic appeared to have a slight advantage. However as the season progressed the plants mulched with black plastic progressively outperformed the other treatments.

Weed populations were effectively reduced by Alanap-3 used alone and in combination with asphalt-clear plastic and asphalt mulches. Fruit set per plant was greater with than without Alanap-3 used in conjunction with all mulch treatments except black plastic.

All mulching treatments increased the total yield per acre and the size of harvested fruit over the non-mulched control. The greatest increase in yield and fruit size was with black plastic. Alanap-3 used with asphalt and the non-mulched control increased the yield of both crops over no Alanap-3 with the same mulch treatments.

In summary asphalt mulch and Alanap-3 improved yields slightly, and black plastic mulch increased yields of curcurbits substantially.